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Rare Decays and Search for New Physics with *BABAR*

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Abstract

Rare B decays permit stringent tests of the Standard Model and allow searches for new physics. Several rare radiative-decay studies of the B meson from the *BABAR* collaboration are described. So far no sign for new physics was discovered.

1 Introduction

At the SLAC PEP-II B-Factory, the *BABAR* detector collected so far more than 250M $B\overline{B}$ pairs, created by e^+e^- collisions at the $\Upsilon(4S)$ resonance. This data set makes searches for rare decays feasible at branching fractions (BF) of 10^{-4} or less. This talk concentrates on radiative B decays. Additional results from *BABAR* were discussed elsewhere at this conference. [1]

2 Fully- and Semi-inclusive $B \to X_s\gamma$, $B \to K^*(892)\gamma$ & $B \to K_2^*(1430)\gamma$

The lowest-order Feynman diagram of $b \to s\gamma$ is a one-loop electromagnetic penguin, in which non-Standard Model (non-SM) virtual particles (like the Higgs) might influence the decay rate. Measuring the energy distribution of the b quark inside the B meson helps extract $|V_{ub}|$ from $B \to X_u l\nu$. The decay $b \to s\gamma$ was studied in inclusive and exclusive modes using $\sim$ 89M $B\overline{B}$ pairs.

In the so-called "fully-inclusive" measurement only the photon of $B \to X_s\gamma$ needs to be detected, but large background has to be suppressed. In the "semi-inclusive" measurement, the $B \to X_s\gamma$ BF is determined from 38 exclusive states with about 45% of the total rate estimated to be missing.

The E_γ spectra from the two $B \to X_s\gamma$ analyses are shown in Fig.1. The $K^*\gamma$ peak, prominent at high E_γ for the semi-inclusive analysis, is not visible for the inclusive analysis due to resolution constraints. Fig.2 left plots the fully-inclusive partial BFs against the value of the lower cut in E_γ. The overall semi-inclusive BF, when extrapolated to $E_\gamma > 1.6\,$GeV, agrees with the SM prediction and with the results from other experiments (Fig.2 right). [2, 3]

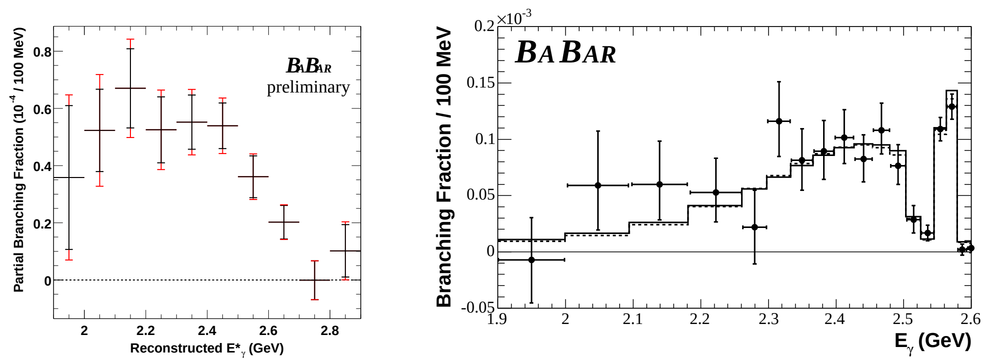

Figure 1: *Photon energy spectrum from fully- (left, in $\Upsilon(4S)$ frame) and semi-inclusive $B \to X_s\gamma$ analyses (right, in B frame, with theory spectra overlaid).*

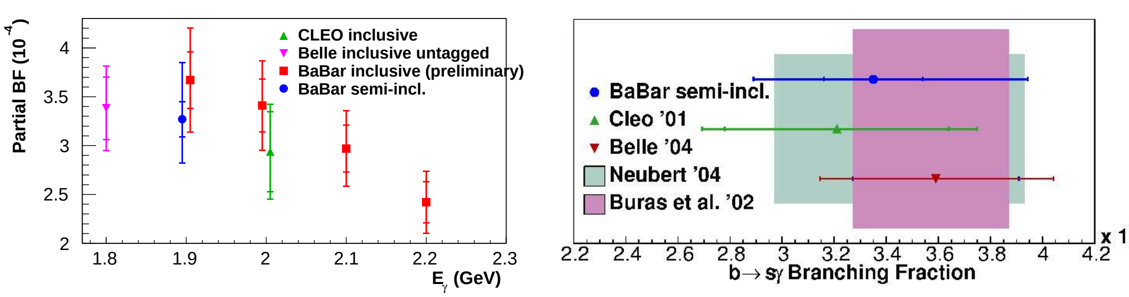

Figure 2: *Partial BFs versus lower cut in E_γ (left) and overall BF measurements (right) of $B \to X_s\gamma$ for $E_\gamma > 1.6\,$GeV.*

Non-perturbative hadronic effects complicate the theoretical calculations of exclusive decays like $B \to K^*(892)\gamma$ and $B \to K_2^*(1430)\gamma$, so that the measurements are currently more accurate than the predictions. A summary of the results is shown in Fig.3. [4, 5]

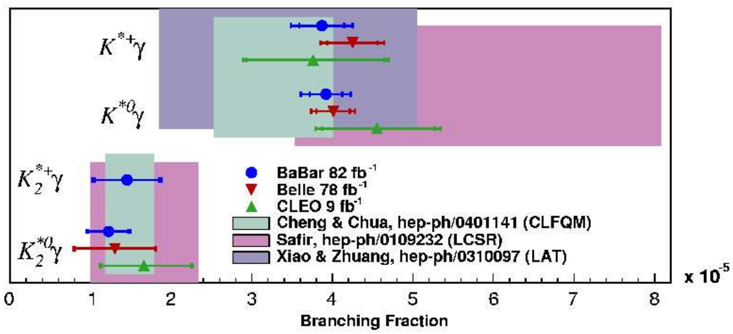

Figure 3: *Branching fractions of $B \to K^*(892)\gamma$ and $B \to K_2^*(1430)\gamma$.*

3 $B \to X_s ll$, $B \to K^{(*)}ll$ and $B \to (\rho, \omega)\gamma$

The decay $b \to sll$ has been measured semi-inclusively ($B \to X_s ll$) on 89M $B\overline{B}$ pairs, and exclusively ($B \to K^{(*)}ll$) on 229M $B\overline{B}$ pairs. The former measurement is again based on a sum of exclusive states, with about half of the total rate missing, and its BF [6] of $(5.6 \pm 1.5 \pm 0.6 \pm 1.1) \times 10^{-6}$ for $m_{ll} > 0.2\,\mathrm{GeV}/c^2$ agrees well with the SM prediction. The exclusive decay results are shown in Fig.4 left. [7]

The decay $b \to d\gamma$ has been studied in 221M $B\overline{B}$ pairs by searching for $B \to (\rho, \omega)\gamma$. These decays go primarily through penguin diagrams, but also through W-exchange or W-annihilation. The background originates mainly from $q\overline{q}$ (=$udsc$) events. The BF results are summarized in Fig.4 right. [8]

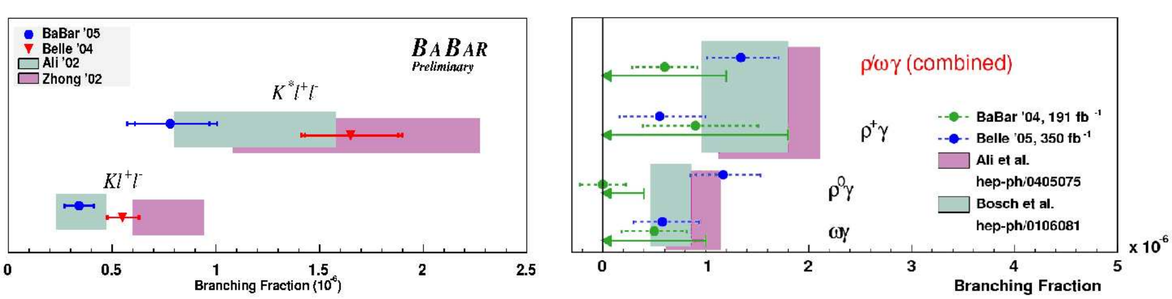

Figure 4: *BF measurements and SM predictions for $K^{(*)}ll$ (left) and $B \to (\rho, \omega)\gamma$ decays (right).*

4 $\overline{B}^0 \to D^{*0}\gamma$ and $B^0 \to \phi\gamma$

The $\overline{B}^0 \to D^{*0}\gamma$ decay with SM predictions around 10^{-6} is dominated by W-exchange. The final B candidates from 88M $B\overline{B}$ pairs are described by $m_{\rm ES} = \sqrt{E^{*2}_{\rm beam} - p^{*2}_B}$ and $\Delta E^* = E^*_B - E^*_{\rm beam}$, with $E^*_{\rm beam}$ being the center-of-mass (CM) beam energy, and E^*_B and p^{*2}_B the B candidate's CM energy and momentum. Background, mainly from $B\overline{B}$ decays, is estimated to be 9.4 ± 1.7 events in the $m_{\rm ES}$-ΔE signal box. Thirteen observed data events (Fig.5 left) lead to a BF upper limit of 2.5×10^{-5} at 90% confidence level (CL). [9)]

The experimental signature of the $B^0 \to \phi\gamma$ decay is clean, but the SM prediction of the BF is very low with 3.6×10^{-12}. Candidates are selected from 124M $B\overline{B}$ pairs. In the signal region, a $q\overline{q}$ ($B\overline{B}$) background of 6.0 ± 1.0 (<0.1) events is expected. Eight events observed in data (Fig.5 right) result in a BF upper limit of 8.5×10^{-7} at 90% CL. [10)]

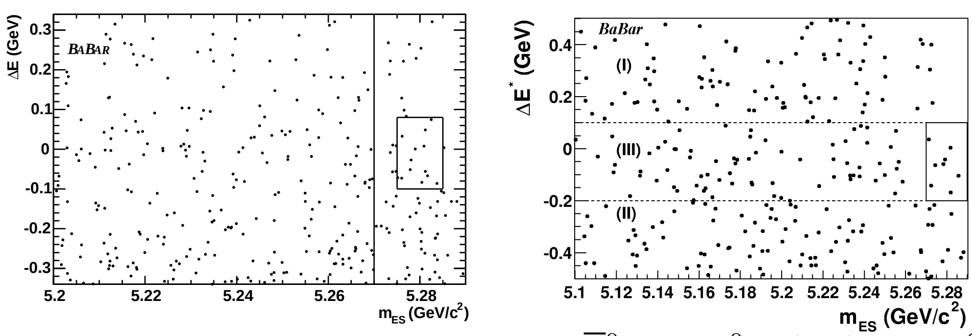

Figure 5: *$m_{\rm ES}$-ΔE plane of real data for $\overline{B}^0 \to D^{*0}\gamma$ (left) and $B^0 \to \phi\gamma$ (right). In both plots the signal box is indicated on the right side.*

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